

# REPORT DOCUMENTATION PAGE

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MEMORANDUM FOR PRR (Contractor/In-House Publication)

FROM: PROI (TI) (STINFO)

20 May 1999

SUBJECT: Authorization for Release of Technical Information, Control Number: AFRL-PR-ED-TP-FY99-0106  
Jay Levine, "Plume Phenomenology Program"

International presentation

~~(Foreign Release)~~ Dist A



# PLUME PHENOMENOLOGY PROGRAM

## ONERA

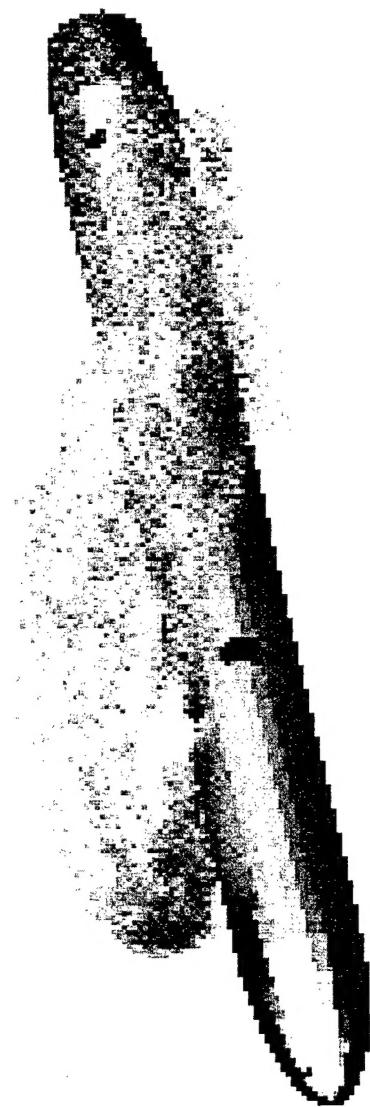
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4 June 1999



# Plume-Vehicle Interactions

## Jet Interaction Effects - Body Heating, Aerodynamic Forces



# AFRL Propulsion Directorate



## Propulsion Sciences and Advanced Concepts Division

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| <p><b>Aerophysics</b><br/>CHIEF: Mr. Jay Levine</p>  | <p><b>Propulsion Materials Applications</b><br/>CHIEF: Dr. Shawn Phillips</p>   | <p><b>Propellants</b><br/>CHIEF: Dr. Pat Carrick</p>  | <p><b>Applications &amp; Assessment</b><br/>ASSOC CH: Dr. Tae Woo Park</p>  |
| <ul style="list-style-type: none"><li>• Rocket plume phenomenology</li><li>• Combustion processes and devices</li><li>• Spray combustion</li><li>• Energetic-material decomposition</li><li>• Plasma discharges</li><li>• Computational fluid dynamics</li><li>• Supercritical fluid mechanics</li><li>• Rarefied gas dynamics</li><li>• Non-equilibrium flows</li></ul> | <ul style="list-style-type: none"><li>• Advanced polymeric components</li><li>• Hybrid polymers</li><li>• Advanced component fabrication techniques</li><li>• Carbon-carbon components</li><li>• High temperature coatings</li><li>• Nanocrystalline materials</li><li>• Functionally graded components</li><li>• Solid-propellant fracture mechanics</li><li>• Microtube technology</li><li>• Ceramic processing</li></ul> | <ul style="list-style-type: none"><li>• High energy-density matter</li><li>• Liquid rocket propellants and additives</li><li>• Solid and hybrid rocket motors and propellants</li><li>• Cryogenic propellants</li><li>• Energetic molecule synthesis and characterization</li><li>• Computational chemistry</li><li>• Analytic chemistry</li><li>• Environmental propulsion technology</li><li>• Propellant hazard analysis</li><li>• Missile safety</li><li>• Advanced propulsion concepts</li></ul> | <ul style="list-style-type: none"><li>• System-level performance analysis of aerospace vehicles</li><li>• Flight trajectory simulations</li><li>• Liquid rocket power balance analysis</li><li>• Vehicle flight performance prediction</li><li>• Propellant requirement estimation</li><li>• Technical risk assessment</li><li>• Reliability analysis</li><li>• Program cost estimation</li></ul> |



## **...What We Do**

- Primary U.S. Activity for Plume Related Signature Modeling and Analysis
- Develop and Validate Plume Codes for Distribution to DoD Community
  - Propulsion Performance
  - Exhaust Plume Characteristics and Signatures
- Both In-House and Contracted Work
  - **Substantial In-House Computing and Scientific Visualization Capabilities**



## Background

### Types of Plume Signatures

- Propulsion Systems Produce the Following Signatures
  - Exhaust Plumes
  - Plume/Body Interactions
- These Signatures can Impact the Effectiveness of a Missile Defense System During Boost, Ascent, and Descent Phases



## Background

### Plumes Impact Many Missile Defense Functions

- **Passive Signatures:** Emissions in the UV-LWIR (0.1-25  $\mu\text{m}$ )
  - Detection, Acquisition, Tracking, Typing, Cueing, Handover, Aim-point Selection, Band Pass Selection, Sensor Ranging
- **Active Signatures:** Laser and Radar Attenuation and Backscatter
  - All Weather Detection and Tracking, Typing, Communications, Aim-point Selection, and Sensor Ranging
- **Vehicle/Plume Interactions**
  - Base Heating, Engine Heat Sink, Pressure Distribution, Flow Separation, Shocks, and Contamination

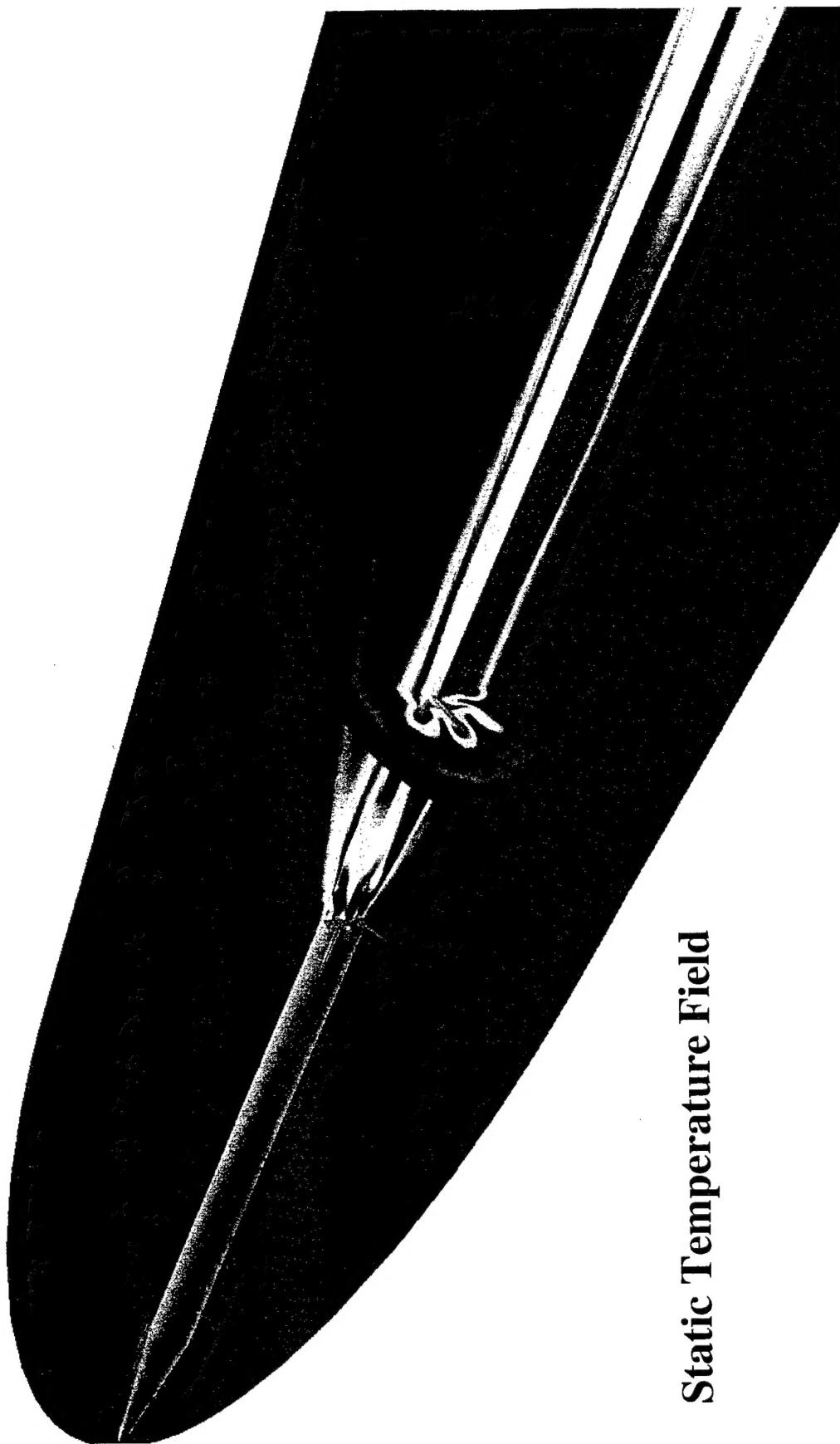


## Plume Phenomenology Implications: A Few Examples

- **Plume Asymmetries**
  - 3-D Effects (Fins, Gas Generators, TVC vanes, etc)
  - Angle-of-Attack
- **Afterburning Cessation and Shutdown**
- **Contamination**



## 3-D Simulations of Plume Flows



Static Temperature Field



## 3-D Radiation Predictions

